

WHAT IS CLAIMED IS:

1. A method of sorting plant products based on damage to the plant products, the method comprising the steps of:

emitting an illumination light toward an outer surface of a plant product;

detecting substantially a single wavelength of a reflected light produced by the plant product responsive to the illumination light;

determining at least one of a presence, an amount, and a severity of damage responsive to the reflected light; and

assigning a damage category to the plant product responsive to the determination of damage.

2. The method of Claim 1, wherein the step of emitting an illumination light includes:

emitting an illumination light having substantially a single wavelength.

3. The method of Claim 1, wherein the step of determining at least one of a presence, an amount, and a severity of damage responsive to the reflected light includes:

determining at least one of a presence, an amount, and a severity of at least one of decay, pre-harvest mechanical damage, post-harvest mechanical damage, blemish, stems, blossoms, firmness, or water content of the plant product.

4. The method of Claim 1, including the steps of:
storing information on the reflected light;

generating an image of a surface of the plant product responsive to the stored information; and

assigning the damage category to the plant product responsive to the generated image.

5. The method of Claim 1, including the step of:

directing the plant product to one of two or more predetermined locations based upon the damage category of the plant product.

6. The method of Claim 1, wherein the plant product is at least one of a non-citrus fruit, a vegetable, a legume, and a citrus fruit.

7. The method of Claim 1, wherein the single wavelength is substantially within the range of 900 nm to 1100 nm.

8. The method of Claim 1, wherein damage to the plant product reflects less of the illumination light as reflected light than does an undamaged outer surface of the plant product.

9. The method of Claim 1, wherein the steps of determining at least one of a presence, an amount, and a severity of damage responsive to the reflected light; and assigning a damage category to the plant product responsive to the determination of damage are accomplished within a time interval of 80 ms or less.

10. The method of Claim 4, wherein the step of generating an image of a surface of the plant product responsive to the stored information includes the step of:

rotating the plant product about an axis at a predetermined rotation rate.

11. The method of Claim 1, wherein the step of detecting substantially a single wavelength of a reflected light produced by the plant product responsive to the illumination light includes the steps of:

moving the plant product in a first travel direction; and

detecting the reflected light substantially along a line perpendicular to the first travel direction.

12. An apparatus for inspecting plant products for damage to the plant products, comprising:

a first beam emitter for providing a first illumination light to a plant product;

a first beam detector for detecting substantially a single wavelength of first reflected light from the plant product and responsively producing a first reflection signal; and

a control unit for receiving at least one first reflection signal and responsively assigning a damage category to the plant product; wherein

the control unit determines at least one of a presence, an amount, and a severity of damage responsive to the first reflection signal and assigns the damage category to the plant product responsive to the determination of damage.

13. The apparatus of Claim 12, including:

a second beam emitter for providing a second illumination light to the plant product;
and

a second beam detector for detecting substantially a single wavelength of second reflected light from the plant product and responsively producing a second reflection signal;
wherein

the control unit receives at least one of each of first and second reflection signals and responsively assigns the damage category to the plant product.

14. The apparatus of Claim 12, wherein the control unit generates an image of the plant product responsive to the first reflection signal.

15. The apparatus of Claim 14, wherein the plant product is rotated about an axis at a predetermined rotation rate and the control unit generates an image of substantially an entire outer surface of the plant product.

16. The apparatus of Claim 12, wherein the control unit includes a processor, a memory, and at least one software instruction.

17. The apparatus of Claim 13, wherein the control unit generates an image of the plant product responsive to the first and second reflection signals.

18. The apparatus of Claim 16, wherein the control unit includes software instructions for at least one of: beam emitter control, beam detector control, reflection signal

storing, reflection signal combining, reflection signal analysis, image generation, damage assessment, damage category assignation, and plant product routing.

19. The apparatus of Claim 12, including:

a conveyor system to carry one or more plant products past the first beam emitter and the first beam detector.

20. The apparatus of Claim 19, wherein the conveyor system is operative to rotate each plant product about an axis at a predetermined rate as the plant product is moved past the first beam emitter and the first beam detector.

21. The apparatus of Claim 12, wherein the first beam emitter provides a first illumination light of substantially a single wavelength.

22. The apparatus of Claim 13, wherein the second beam emitter provides a second illumination light of substantially a single wavelength.

23. The apparatus of Claim 12, wherein the first beam emitter is at least one of a laser, a light-emitting diode, a broad-spectrum lamp, and a broad-spectrum lamp including a filter and wherein the first beam detector is at least one of a photodiode, a camera, a camera including a filter, and a CCD sensor.

24. The apparatus of Claim 12, wherein the first beam emitter is a laser of the diode type.

25. The apparatus of Claim 13, wherein the second beam emitter is at least one of a laser, a light-emitting diode, a broad-spectrum lamp, and a broad-spectrum lamp including a filter and wherein the second beam detector is at least one of a photodiode, a camera, a camera including a filter, and a CCD sensor.

26. The apparatus of Claim 13, wherein the second beam emitter is a laser of the diode type.

27. The apparatus of Claim 12, wherein the single wavelength of the first reflected light is substantially within the range of 900 nm to 1100 nm.

28. The apparatus of Claim 13, wherein the single wavelength of the second reflected light is substantially within the range of 900 nm to 1100 nm.

29. The apparatus of Claim 12, wherein the single wavelength of the first reflected light is 980 nm.

30. The apparatus of Claim 13, wherein the single wavelength of the second reflected light is 980 nm

31. The apparatus of Claim 12, wherein the plant product is at least one of a non-citrus fruit, a vegetable, a legume, and a citrus fruit.

32. The apparatus of Claim 12, wherein the damage is at least one of decay, pre-harvest mechanical damage, post-harvest mechanical damage, blemish, stems, blossoms, firmness, or water content of the plant product.

33. The apparatus of Claim 12, wherein damage to the plant product reflects less of the first illumination light as first reflected light than does an undamaged outer surface of the plant product.

34. The apparatus of Claim 13, wherein damage to the plant product reflects less of the second illumination light as second reflected light than does an undamaged outer surface of the plant product.

35. The apparatus of Claim 19, wherein the conveyor system directs the plant product to one of two or more predetermined locations based upon the damage category of the plant product.

36. The apparatus of Claim 12, wherein the first beam emitter provides a line of first illumination light perpendicular to a direction of plant product travel.

37. The apparatus of Claim 36, wherein the first beam emitter provides the line of first illumination light by at least one of: scanning a point of first illumination light along a predetermined path, and passing the first illumination light from a first light source through an optical device to concurrently form a line of first illumination light.

38. The apparatus of Claim 12, wherein the first beam detector detects a line of first reflected light perpendicular to a direction of plant product travel, and the control unit combines multiple first reflection signals to responsively generate a determination of damage of the plant product.

39. The apparatus of Claim 12, wherein the first beam detector detects an area of first reflected light.

40. The apparatus of Claim 13, wherein the second beam emitter provides a line of second illumination light perpendicular to a direction of plant product travel.

41. The apparatus of Claim 40, wherein the second beam emitter provides the line of second illumination light by at least one of: scanning a point of second illumination light along a predetermined path, and passing the second illumination light from a second light source through an optical device to concurrently form a line of second illumination light.

42. The apparatus of Claim 13, wherein the second beam detector detects a line of second reflected light perpendicular to a direction of plant product travel, and the control unit combines multiple first and second reflection signals to responsively generate a determination of damage for substantially an entire surface of the plant product.

43. The apparatus of Claim 13, wherein the second beam detector detects an area of second reflected light.

44. An apparatus for sorting plant products based on damage, comprising:
means for determining, responsive to substantially a single wavelength of light, at least one of a presence, an amount, and a severity of damage to a surface of the plant product;
and
means for sorting the plant products into one of two or more damage categories responsive to the determination of damage.

45. The apparatus of Claim 44, wherein the means for determining includes at least one of means for generating an illumination light of substantially a single wavelength, and means for detecting a reflected light of substantially a single wavelength.

46. The apparatus of Claim 44, wherein the single wavelength is substantially within the range of 900 nm to 1100 nm.

47. The apparatus of Claim 44, wherein the plant product is at least one of a non-citrus fruit, a vegetable, a legume, and a citrus fruit.

48. The apparatus of Claim 44, wherein the damage is at least one of decay, pre-harvest mechanical damage, post-harvest mechanical damage, blemish, stems, blossoms, firmness, or water content of the plant product.

49. The apparatus of Claim 44, wherein damage to the plant product reflects less of the single wavelength of light than does an undamaged outer surface of the plant product.

50. The apparatus of Claim 44, including means for moving the plant product relative to the means for determining such that a surface of the plant product is exposed to the means for determining.

51. The apparatus of Claim 50 wherein the means for moving includes a means for rotating which rotates the plant product about an axis at a predetermined rate.

52. An apparatus for scanning a plant product to detect damage to the plant product, comprising:

at least one beam emitter for providing an illumination light to the plant product;

at least one beam detector for detecting a reflected light from the plant product and responsively producing at least one reflection signal; and

a control unit for receiving the at least one reflection signal and responsively generating a plant product image;

wherein the reflected light has substantially a single wavelength and wherein damage to the plant product is detected responsive to the plant product image.

53. The apparatus of Claim 52, wherein the beam emitter is a laser.

54. The apparatus of Claim 52, wherein the single wavelength is substantially within the range of 900 nm to 1100 nm.

55. The apparatus of Claim 52, wherein the control unit combines multiple reflection signals to produce a plant product image of substantially an entire surface of the plant product.

56. The apparatus of Claim 52, wherein the at least one beam detector detects the reflected light substantially along a detection line.

57. The apparatus of Claim 56, wherein the plant product is moving along a product line substantially perpendicular to the detection line.

58. The apparatus of Claim 52, wherein the plant product is rotated about an axis at a predetermined rotation rate to provide a plant product image of a surface of the plant product.